INTRODUCTION:
It has been estimated that more than 300,000 anterior cruciate ligament (ACL) injuries occur annually in the United States with over 100,000 of these patients opting for surgical reconstruction. Good to excellent subjective results following primary ACL reconstruction can be expected in the majority of patients, and more than half will return to their pre-injury level of athletic participation. Those patients that return to high-risk activities, such as sports that involve rapid deceleration and cutting maneuvers (football, basketball, soccer, and skiing), will be at higher risk for failure though. As the number of primary ACL reconstructions increases, naturally so does the number of failures and thus the necessity for revision procedures.

When compared to primary ACL reconstruction, an inferior outcome can often be expected with a revision procedure. Clinical failures have been noted in up to 33% of patients with return to pre-injury level of activity being as low as 54% of patients. Even though the clinical results are often inferior, there is considerable evidence to suggest that knee stability comparable to a primary reconstruction can be achieved in the revision setting. To achieve optimum results, a well-executed preoperative plan and surgical technique are critical. Our objective is to describe the associated meniscal and chondral injuries noted at the time of revision surgery, the status of the primary graft, and the management of bone tunnels. Finally, we also detail our preferred treatment plan and discuss the technical considerations of revision surgery.

METHODS:
Data collection. Retrospective review of the senior surgeons' operative logs identified 173 patients who underwent a revision ACL reconstruction between 1999-2010. Twenty patients had a multi-ligamentous injury at the time of native ACL injury or a previous revision surgery and were excluded. Data were obtained on the remaining 153 patients via retrospective chart review. The average time from primary to revision ACL reconstruction was 6.5 (0.5-24.3 ± 5.5) yrs, and the average age at the time of revision was 32.6 (15.8-71.7 ± 11.1) yrs.

Surgical technique. The endoscopic single-incision technique was used for our revision reconstructions. Standard arthroscopic portals were created and any meniscal pathology was addressed followed by debridement of any residual graft. The intra-articular position of the tibial and femoral tunnels was then assessed and a notchplasty was performed if the width of the notch was less than 15mm in diameter. If either interference screw was thought to interfere with the drilling of the revision tunnel, it was removed. When metal or poly-L-lactic acid (PLLA) screws were encountered, the screw was often removed and replaced with a bone composite screw in an effort to avoid falling into a defect. It has been our experience that a well-fixed bone composite screw can be reamed without difficulty and rarely poses a problem when preparing a revision tunnel.

The intra-articular position of the tibial tunnel was placed in the location of the native footprint, along the down-slope of the medial tibial spine at the level of the posterior border of the anterior horn lateral meniscus. This typically corresponds to a position approximately 8mm anterior to the tibial insertion of the PCL. The femoral tunnel was placed in the 10-10:30 or the 1:30-2 position on the clock face, for the right and left knees, respectively. If a previous tunnel or interference screw prevents the initial use of a 10 or 11mm reamer, then appropriate tunnel positioning can be achieved with sequential reaming, starting with a smaller reamer. The over-the-top guide was inserted through the tibial tunnel. A 6mm offset reamer was typically used to ensure a 1mm cut of the tunnel. Finally, we also detail our preferred treatment plan and discuss the technical considerations of revision surgery.

RESULTS:
The graft utilized at the time of primary ACL reconstruction was bone-patellar tendon-bone (BPTB) autograft (49%), hamstring autograft (23%), or allograft (28%). The graft utilized during revision was BPTB allograft (79%), BPTB autograft (20%), or hamstring autograft (1%). Knee instability following primary ACL reconstruction was related to a macrotraumatic event in 59% of patients, whereas the remaining patients had no identifiable reinjury and the failure was thought to be related to technical errors or failure of incorporation. At the time of revision surgery, 96 patients (63%) had evidence of meniscal injury and 75% had significant chondral damage; patellofemoral compartment (50%), medial compartment (48%), and lateral compartment (21%). The graft was completely disrupted (69%), partially torn (7%), or intact but attenuated (22%). In three patients (2%), a competent graft was sacrificed due to non-anatomic tunnel placement leaving a defect (15%). Additional tibial fixation with a post was necessary in 4% of patients.

DISCUSSION:
The current literature on revision ACL reconstruction contains primarily heterogeneous groups of patients treated by multiple surgeons with varying techniques. Compared to our series, previous studies have reported fewer associated meniscal tears (44% vs. 48%) and chondral damage (52% vs. 21%) seen at the time of revision. Technical failure has been cited as a cause of failure in up to 75% of failed ACL reconstructions which is consistent with our study where 65% of tibial tunnels and 80% of femoral tunnels were revised. A macrotraumatic event was noted as a cause of failure in 22% and 18% previously, which is lower than in our study (59%). Additionally, failure due to loss of secondary restraints was found in 7/54 vs. 3/56 which is higher than in our study (1/153).

Our study represents the largest cohort of revision ACL reconstructions in the literature. With our increasingly active population we will be faced with a larger number of failed ACL reconstructions. When approaching these patients, the potential causes of failure must be evaluated and addressed. Often, multiple causes for failure were identified but technical failure was most common. Thus, non-anatomic tunnels are often encountered and should not be re-used. BPTB is typically our graft of choice and tunnel widening may need to be addressed with either allograft or bone substitute. Adequate fixation can typically be achieved using an interference screw, but additional tibial fixation may be required. Interestingly, failure due to a macrotraumatic event was relatively high whereas failure due to loss of secondary restraints was relatively uncommon in our series. This may represent a high rate of return to activity following primary reconstruction, but future studies are required to confirm this finding.

REFERENCES: